

RD-A169 483

COMPONENT IMPROVEMENT PROGRAM TASK 83-01 36E133 AIR
TURBINE STARTER(U) ALLIED BENDIX AEROSPACE UTICA NY
FLUID POWER DIV L WILLIAMS FEB 86 8720-3173U

1/1

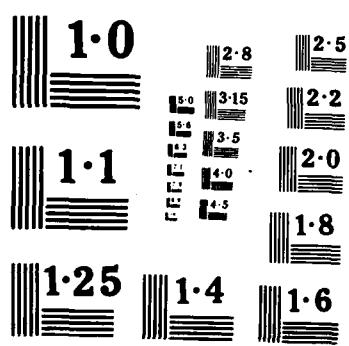
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AD-A169 483

Bendix Fluid Power Division

Report No. 8720-3173U

Component Improvement Program
Task 83-01
36E133 Air Turbine Starter

February, 1986

Contract No. N00019-80-G-0607-XU04

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Component Improvement Program
Task 83-01
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February, 1986

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Prepared for:
Department of the Navy
Naval Air Systems Command
Washington, DC

APPROVED FOR PUBLIC RELEASE:
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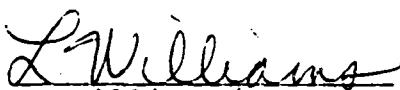
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SCOPE

This report describes the analysis and results of the first half of Task 83-01, "Solid State Electronic Cutout Switch for the 36E123 (A-29) and 36E133 (A-28) Starters", conducted in accordance with NAVAIR Contract No. N00019-80-G-0607-XU04.

All analysis and initial phase testing was performed by the Engineering Department of Allied Signal Corporation, Bendix Fluid Power Division at Utica, New York.

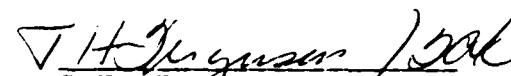
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1.0 INTRODUCTION

The subject air turbine starters (ATS), Bendix Type 36E133 ATS and Type 36E123 ATS were designed to comply with MIL-S-19557, 8 and 9, respectively. The automatic cutoff control for both starters, as permitted by Paragraph 3.5.7 of the aforementioned specification, was designed to sense the speed of the starter's output drive. The existing control is a fly-weight type governor which acts to open an electrical switch at the predetermined cutout speed.

While the device has some definite advantages, field service has demonstrated that they are overridden by the following:

- The location of the governor (buried in the front end of the starter) makes it very difficult to service in the field.
- The mechanical elements are negatively influenced by the vibrational environment of the starter and engine.
- The electrical leads, which must be snaked through "tortuous" paths and small holes from the external connector to the switch, has caused insulation to be stripped from the leads, shorting out the switch.

In the recent past, Bendix has designed and developed an electronic solid-state "cutout switch" for turbine starters. This totally electronic device, typically monitors starter turbine speed and acts to terminate the start cycle at the turbine equivalent to the specified cutout speed.

These electronic devices are potted to isolate the components from environmental affects and the devices can be mounted externally of the starter to permit easy replacement, if necessary, or to put them in an environmentally favorable location.

Field experience has demonstrated that these electronic cutout switches are far superior to the mechanical devices.

The effort described herein was performed to adapt an existing, service proven, switch to the 36E133-4A starter, S/N 1501, supplied by the NAVY. The new starter configuration is a 36E133-6A (reference Figure 3).

2.0 TASK DESCRIPTION

2.1 Objective

Replace mechanical cutout switch with a solid-state electronic cutout switch to improve accuracy and reliability of the automatic start cycle termination in the S-3A and F-14A aircraft.

2.2 Work Statement

The program consisted of the following steps:

1. Evaluate feasibility of adapting a production Bendix solid state electronic switch for this application.
2. Propose design changes necessary to adopt electronic switch.
3. Prepare detail drawings of proposed switch and modified/new parts.
4. Fabricate one set of parts for test evaluation. Would include breadboard switch assembly.
5. Run development test on breadboard system.
6. Fabricate cutout switch mockup and check installation of starter on aircraft.
7. Complete design changes/detail drawings of proposed switch.

8. Fabricate final design of switch and associated hardware. (Reference Appendix 2).
9. Perform qualification test on final design. Test would include environmental tests.
10. Prepare final reports, to include ECP submittal.

3.0 ANALYSIS

The 36E133-4A starter (see Figure 1) is the latest Bendix configuration starter being used on the F-14A aircraft. This starter has a fly weight governor-type cutout (c/o) switch. (See Figure 2).

A more recently designed Bendix starter, currently in use on the KC-135R aircraft re-engined with the CFM56-2 engine, uses an electronic cutout switch on a highly similar turbine and gear reduction system. The high degree of similarity between this starter and the subject starters (36E123 ATS and 36E133 ATS) make the electronic device a prime candidate for adapting to subject units.

3.1 The following is a list of advantages of the electronic cutout switch over the mechanical/governor type cutout switch.

3.1.1 The electronic switch selected for the 36E133 starter is the same proven circuit presently being used on the Bendix KC-135R starter. Only a minor resistor change needed to be made.

3.1.2 The electronic cutout switch is bench set and tested easily and accurately before being installed in the starter. Conversely, the mechanical switch normally requires an adjustment involving a disassembly of the starter output spline. This is an unreliable, awkward and time consuming procedure.

- 3.1.3 The electronic device provides a positive, sharp and consistent break in the electrical circuit, while that provided by the mechanical governor is highly influenced by the varying friction of it's mechanical components.
- 3.1.4 Should the electronic switch need to be replaced, that can be done easily without removing the starter from the engine.

4.0 ELECTRONIC SWITCH DESCRIPTION

The function of the cutout switch is to terminate the start cycle at a predetermined speed. An electromechanical speed sensing device is used to terminate the start cycle. The device is similar to many we have and are currently providing on other military aircraft start systems. Experience has demonstrated that the electronic devices are more reliable than the mechanical, flightweight devices.

The device consists of the following major elements:

- ° An electric relay - aircraft power is connected to the contacts only. The relay coil is powered by a small fixed stator coil generator in the starter.
- ° A single pole, magnet-fastened to the starter turbine shaft, rotated in the generator stator coil.
- ° A small electronic package - also powered by the generator, encapsulated in a potting compound and mounted in a small metal box, fastened to the starter gear housing. (See Figures 3, 4 and 5).

In operation, airframe power is applied to the starter control valve through the normally closed contacts of the relay. This arrangement permits the use of existing airframe wiring.

The small generator incorporated in the starter manifold produces an electric output in terms of power and frequency that is a direct function of turbine rotative speed and is more than ample to power the circuit and relay.

The output of the generator is directed to the electronic package through a short length of shielded cable furnished with the starter.

The output of the generator:

- Powers the electronic circuit in which the instantaneous turbine speed in terms of frequency is compared to a frequency equivalent to starter cutout speed.
- Powers the coil of the relay (normally de-energized - see Figure 6) when the electronic circuit switches it on at cutout speed.

Essentially, a part of the circuit develops a fixed pulse signal, whose frequency is equivalent to starter cutout speed relative to the starter turbine. This signal is compared to the varying frequency equivalent to the instantaneous turbine speed.

When that signal from the turbine is equal to, or less than that of the fixed pulse generator, the relay is switched on, opening the airframe circuit to the starter valve and terminating the start cycle. The relay will remain "on" with its contacts open for a short period as the starter turbine begins to coast down in speed. Latching circuits typically provided in the airframe prevent inadvertent recycling of the starter.

5.0 CONCLUSIONS

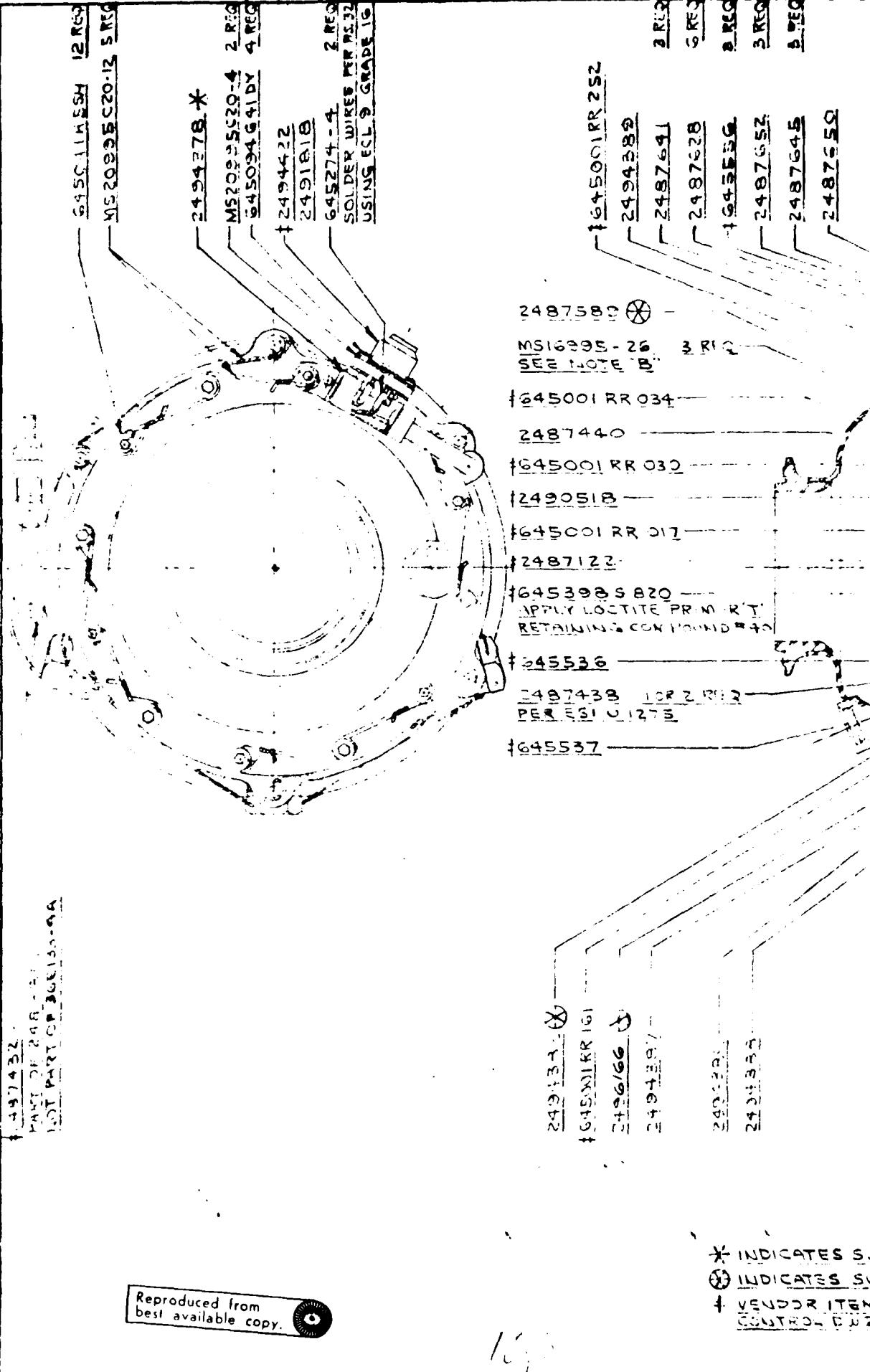
- 5.1 The existing electronic circuit can be used for the 36E133/123 with only a minor resistor change to accommodate the subject unit's cutout speed.
- 5.1 Breadboard testing was successfully completed and satisfactorily demonstrated feasibility.
- 5.3 The suitability of the configuration selected was demonstrated by a successful mock-up on F-14A at Oceana Naval Air Station.
- 5.4 A failure, which occurred at about the eight hundredth cycle of a two thousand start cycle test, was not the fault of the cutout switch. The switch was found to be in excellent condition.
- 5.5 The electronic switch is available to complete the endurance evaluation program.

6.0 RECOMMENDATIONS

- 6.1 Accept that steps 1 through 8 of the work statement (reference para. 2.2, pg. 3) have been satisfactorily completed.
- 6.2 Complete the remaining defined test program , using the starter that will be employed in accomplishing the objectives of TASK 85-01, Bearing Improvement, as the test vehicle. .

APPENDIX 1

FIGURES 1 through 6



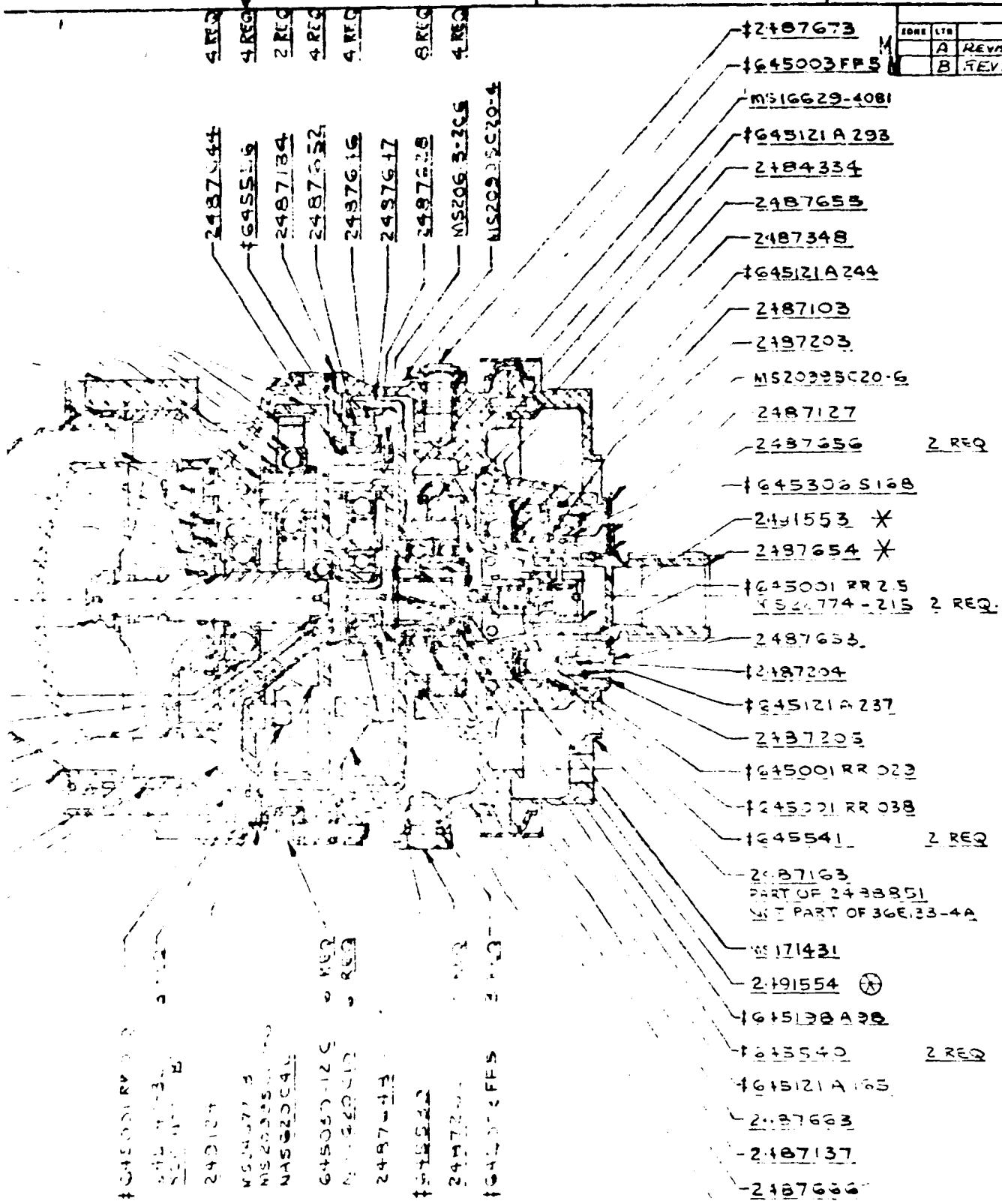
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* INDICATES SUB-ASSEMBLY WITH
 (X) INDICATES SUB-ASSEMBLY OR PART
 + VENDOR ITEM; SEE SOURCE CONTROL
 CONTROL SHEET FOR PRODUCTION

REVISION

DESCRIPTION

ZONE	LTH	A	REVISED SEE CHANGE
		B	REVISED - SEE CHANGE

NOTE "B": APP
TO THREADS PUNLESS OTHER
PARTS ARE CO

FIGURE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES RELATIONSHIPS MUST BE HELD AS SHOWN STANDARDS PER BENDIX SPEC. 7M-1963 A/D WILD 1000	CONTRACT NO. DR. J. E. 5 JAN 78	The Bendix Cor Fluid Power Div Utica, New York
MATERIAL SEE DETAILS	CRD. S. T. K. C. H. N. A. NET WT. 1.000 PROC.	
FINISH SEE DETAILS	ENG. 2 1/2 11/16 1/16 DESIGN ACTIVITY APPROVAL	
APPLICATION	OTM. 1 ACTIVITY APPROVAL	
SCALE 1/1 DRAFTED BY	CODE IDENT. NO. D 99551	

SUB-ASSEMBLY WITH REPLACEABLE COMPONENTS

SUB-ASSEMBLY OF PERMANENT CONSTRUCTION

ENVY; SEE EQUIP. CONTROL OR SPECIF. FOR ENVY

NO. FOR PROCUREMENT ENVY OR PART NUMBER

REPLACEMENT PARTS ARE TO BE USED FOR MAINTENANCE PURPOSES ONLY
REPLACEMENT IS DERIVED FROM THE ORIGINAL EQUIPMENT OR THE EQUIPMENT

STARTER
AIR TURBCODE IDENT. NO.
D 99551

SCALE 1/1 DRAFTED BY

REVISIONS			
LINE	LTR	DESCRIPTION	DATE
1	A	REVISED SEE CHANGE ORDER	1/1/10000
2	B	REVISED - SEE CHANGE ORDER	1/1/20073

MS16629-4081

1645121A293

2494334

2487653

2487348

1645121A244

2487103

-2487203

- MS20393C20-6

2487127

-2487256 2 REQ

-1645300-S168

-2491553 X

-2487654 X

-1645071 RR 25
-1528774-213 2 REQ:

-2487263

-12487204

-1645121A237

-2487223

-1645001 RR 023

-1645121 FR 033

-1645541 2 PER

-2487163

PART OF 24938351

LAST PART OF 36E133-4A.

MS171431

-2491554 ⑤

4645 38236

-1645542 2 REQ

4645121A165

-2487623

-2487137

-2487666

-1645121A37 2 REQ

NOTE "B": APPLY ANTI SEIZE COMPOUND
TO THREADS PER JAN-A-663

UNLESS OTHERWISE SPECIFIED ALL
PARTS ARE COMPONENTS OF 36E133-4A

FIGURE 1

36E133-4QA

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES MUST BE HELD AS SHOWN REF. MIL-STD-16000 SEE DETAILS		CONTRACT NO. DR J. E. 3 JAN 76		The Bendix Corporation Fluid Power Division Utica, New York	
		ITEM		STARTER ASSEMBLY, AIR TURBINE	
		ITEM	ITEM		
		ITEM	ITEM		
		ITEM	ITEM		
SEE DETAILS		SERIAL ACTIVITY APPROVAL		ITEM CODE TODAY NO.	
SEE DETAILS				D 99551	36E133-4QA
SEE DETAILS		OTHER ACTIVITY: FUGAL		SCALE 1/1 PWD LD-6927 MWT 1004 SHEET	

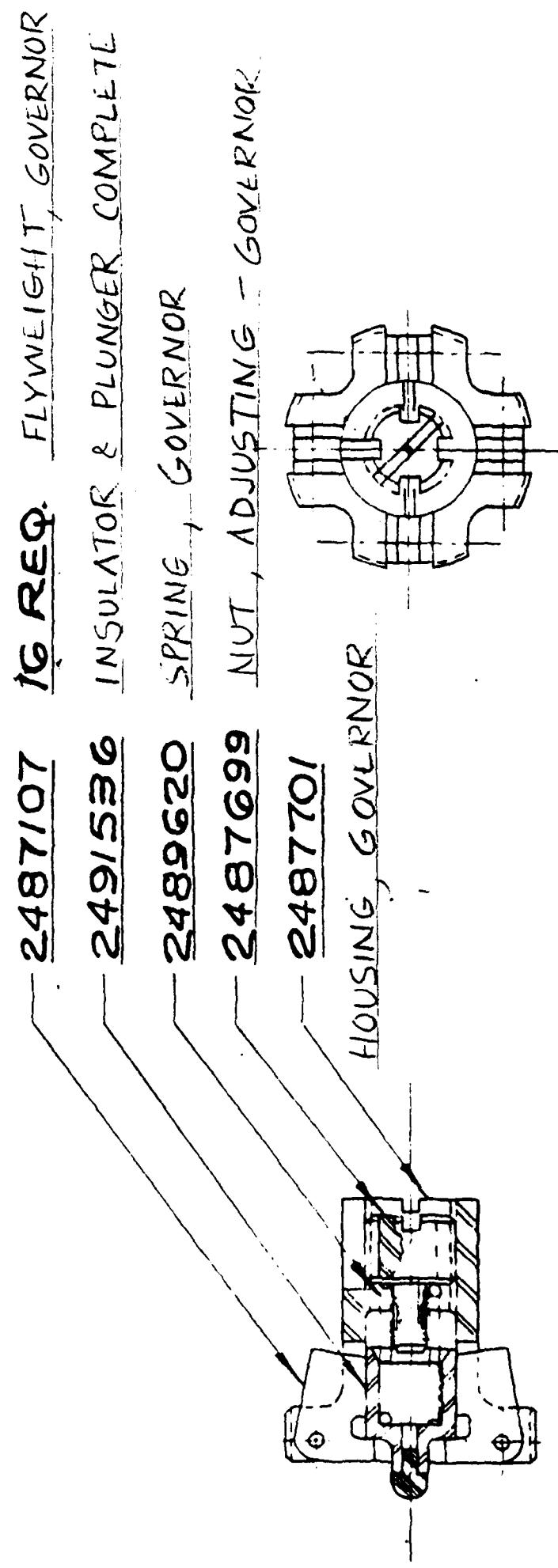


Figure 2 - 36E133-4A Governor
Type.Cutout Switch
P/N 2491553 Assembly

645041G754 8 REQ
MS20225C20-13 8 REQ

CONGREGATION 2 REQ
AN900C01L 2 REQ

2881074 *

1645001 RR 222
2494388
2487641
- 2487628
+ 9455559
2487652
2487645
2487650

3 REQ
GRQ
3 REQ
3 REQ
3 REQ

4 REQ
4 REQ
2487644
+ 9455559

2881075 *

MS-6725-26 3 REQ
SEE NOTE C

1645001 RR 034

2487440

1645001 RR 030

1249051B

1645001 RR 017

2487122

C13103-4 (SEE NOTE C)

248824 (SEE NOTE C)

2881079 (SEE NOTE C)

2483014 (STAKE INTO FL TS)

245536

2487439 1OP 2 PT 3
PER ESI U 12-5

1645537

TORQUE TO 40-45 LB.FT
ABOVE RUNNING TORQUE

1645001 RR 001
2494387
2494386
2494388

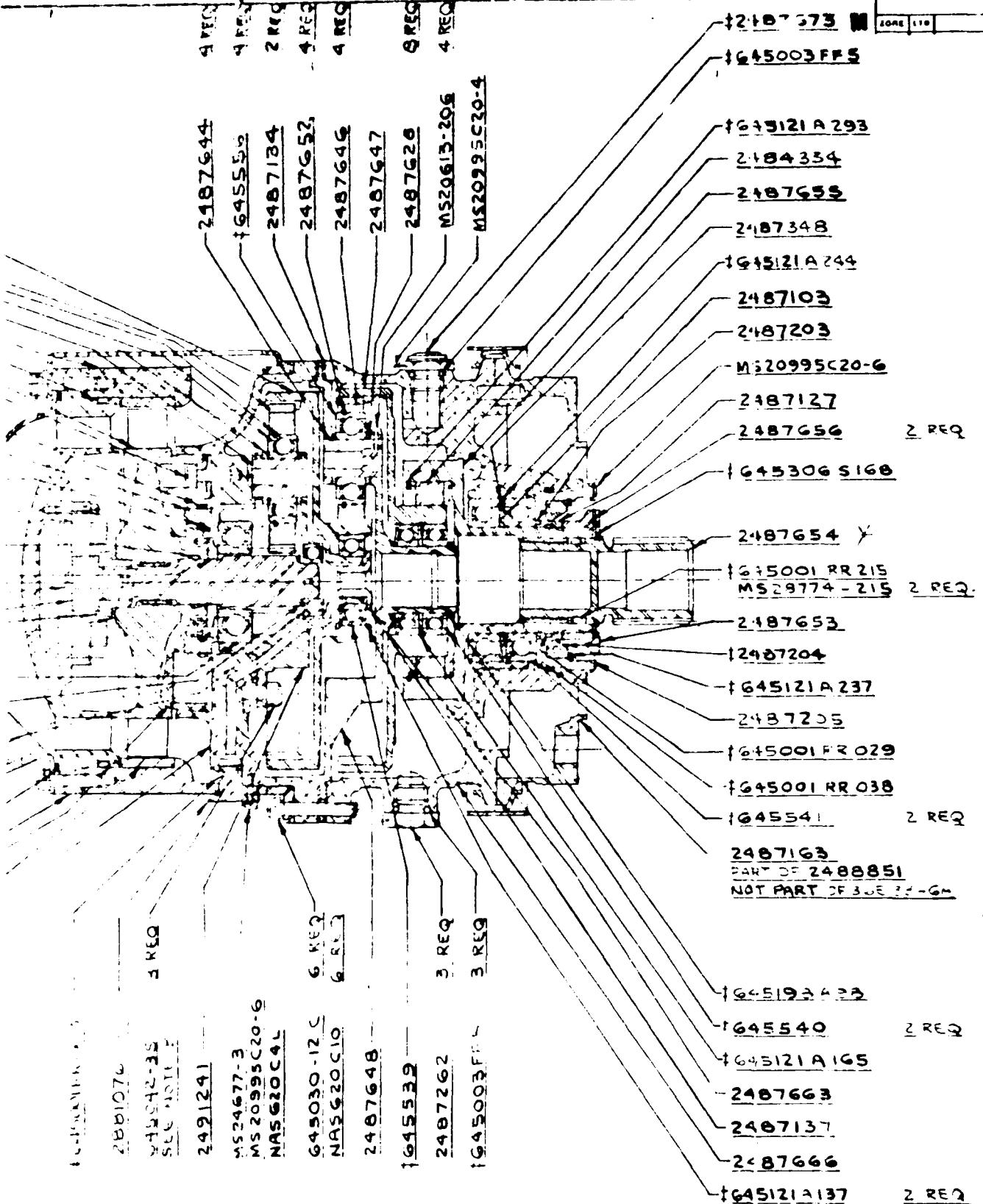
1645001 RR 002
2881076
248042-35 3 REQ
SEE NOTE C
2491291
MS24677-3

491A92
NOT PART OF 3011-6A

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X INDICATES SUB-ASSEMBLY WITH PER
⑧ INDICATES SUB-ASSEMBLY OF PER
+ VENDOR ITEM; SEE SOURCE CONTROL
CONTROL DWG. FOR PROCUREMENT

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PRODUCTION COPY
NOT AN ORIGINAL



SUB-ASSEMBLY WITH REPLACEABLE COMPONENTS

SUB-ASSEMBLY OF PERMANENT CONSTRUCTION

IM; SEE SOURCE CONTROL OR SPECIFICATION

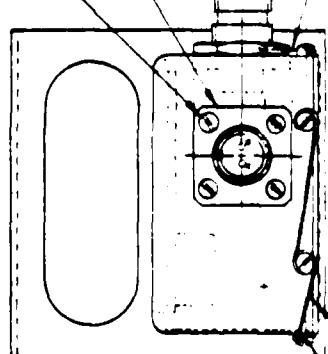
G. FOR PROCUREMENT OF PART NUMBER

"THE USE OF THIS TRADE MARK OR TRADE NAME AND A PART OF THE
COMPANY'S TRADE MARKS ARE SO MARKETED AS TO INDICATE THAT IT IS
NOT INTENDED THAT IT BE USED FOR MANUFACTURING PURPOSES WITHOUT
PERMISSION IN WRITING FROM THE SEVERAL CORPORATIONS TO THE JEWEL."

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES RELATIONSHIPS MUST BE YELD AS SHOWN STANDARDS PER SNOKE SPEC. FOR U903 AND MIL-D-1000	CONTRACT NO.	The Bendix Corp. Fluid Power Division Utica, New York
			DR CW. 10 JAN 55	
	MATERIAL	SEE DETAILS	CR 2 SWY 62115 MET 5 C6 F24 S, TS POLC 12 V 5 C6 TS ENR 2 JAY 27 JAN 55	
	FINISH	SEE DETAILS	DESIGN ACTIVITY APPROVAL	
REKT ASST	USED ON	HEAT TREAT	OTHER ACTIVITY APPROVAL	WEIGHT ACTIVITY NO.
		SEE DETAILS		D - 99551
APPLICATION				SCALE 1/1

		REVISIONS			
ZONE	LTS	DESCRIPTION		DATE	APPROVAL
2487673					
645003 FFS					
645121 A 293					
2484334					
2487655					
2487348					
645121 A 244					
2487103					
2487203					
MS20995C20-6					
2487127					
2487656 2 REQ					
645306 S 168					
2487654 X					
645001 RR 215 MS29774 - 215 2 REQ.					
2487653					
2487204					
645121 A 237					
2487205					
645001 RR 029					
645001 RR 038					
1645341 2 REQ					
2487163 PART OF 2488851 NOT PART OF 3-E 11-6M					
<p style="text-align: center;">NOTE C:</p> <p>CLEAN PARTS THOROUGHLY. APPLY LOCTITE PRIMER T TO MATING SURFACES ALLOW DRY 3 TO 5 MINUTES. APPLY LOCTITE 222 TO MATING SURFACES AND SPREAD IMMEDIATELY. Wipe off EXCESS LOCTITE FROM PARTS ALLOW TO CURE AT ROOM AMBIENT TEMPERATURE FOR FOUR (4) HOURS MIN. BEFORE USE.</p>					
1645193 A 22					
1645540 2 REQ					
1645121 A 165					
2487663					
2487137					
2487666					
645121 A 137 2 REQ					
<p style="text-align: center;">NOTE B:</p> <p>APPLY ANTI SEIZE COMPOUND TO THREADS PER JAN-A-263</p>					
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES RELATIONSHIPS MUST BE HELD AS NOMINAL DEVIATIONS PER MILS SPEC. OR UNLESS NO. 10001000		CONTRACT NO.		The Bendix Corporation Fluid Power Division Utica New York	
SEE DETAILS		CW.	10 JAN 55	STARTER ASSEMBLY, AIR TURBINE <small>FIGURE 3</small>	
		TR.			
SEE DETAILS		645121 A 165	222	DATE CODE: 10001000 D . 99551 36E133-6QA SCALE 1/1 SHEET	
		TR.			
SEE DETAILS		OTHER ACTIVITY APPROVAL			
SEE DETAILS					

SHEET 2 OF 2	
DATE	11/0
TEST	A
REDRAWN	REDRAWN
REVISED	REVISED
MS21042-04	MS21042-04
4 REQ.	4 REQ.
MS3102RIOSLAP	MS3102RIOSLAP
D38999/21RA9-5PN	D38999/21RA9-5PN



MS335275-212 4 REQ

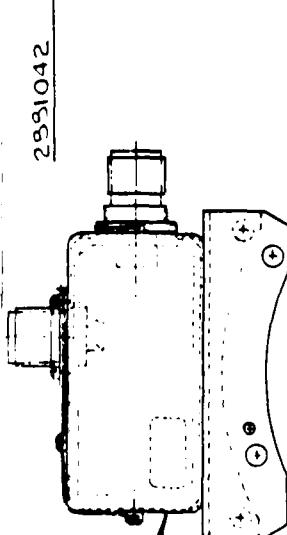
MS20999SC20-5

MS20999SC20-2

FILL BOX WITH EMERSON

AND DUEMLINGS STYCAST
2651 RESIN & CATALYST II
PER ESI-U1382 - FILL TO TOP
OF STIFFENER

28810G5-1
BOND IN PLACE
(SEE NOTE)



28810G8

D38999PAR04PN
RECEPTICLE

INSTALL PIN ONLY
WIRE CONNECTION
NOT USED

FROM
28810G5

MS3102RIOSLAP
A GREEN
B BROWN

2881045
ASSY WITH RELAY
IN POSITION SHOWN

CONNECT LINE A2 SHOWN AND TEST
PER TS U842 BEFORE FILLING
WITH "STYCAST".

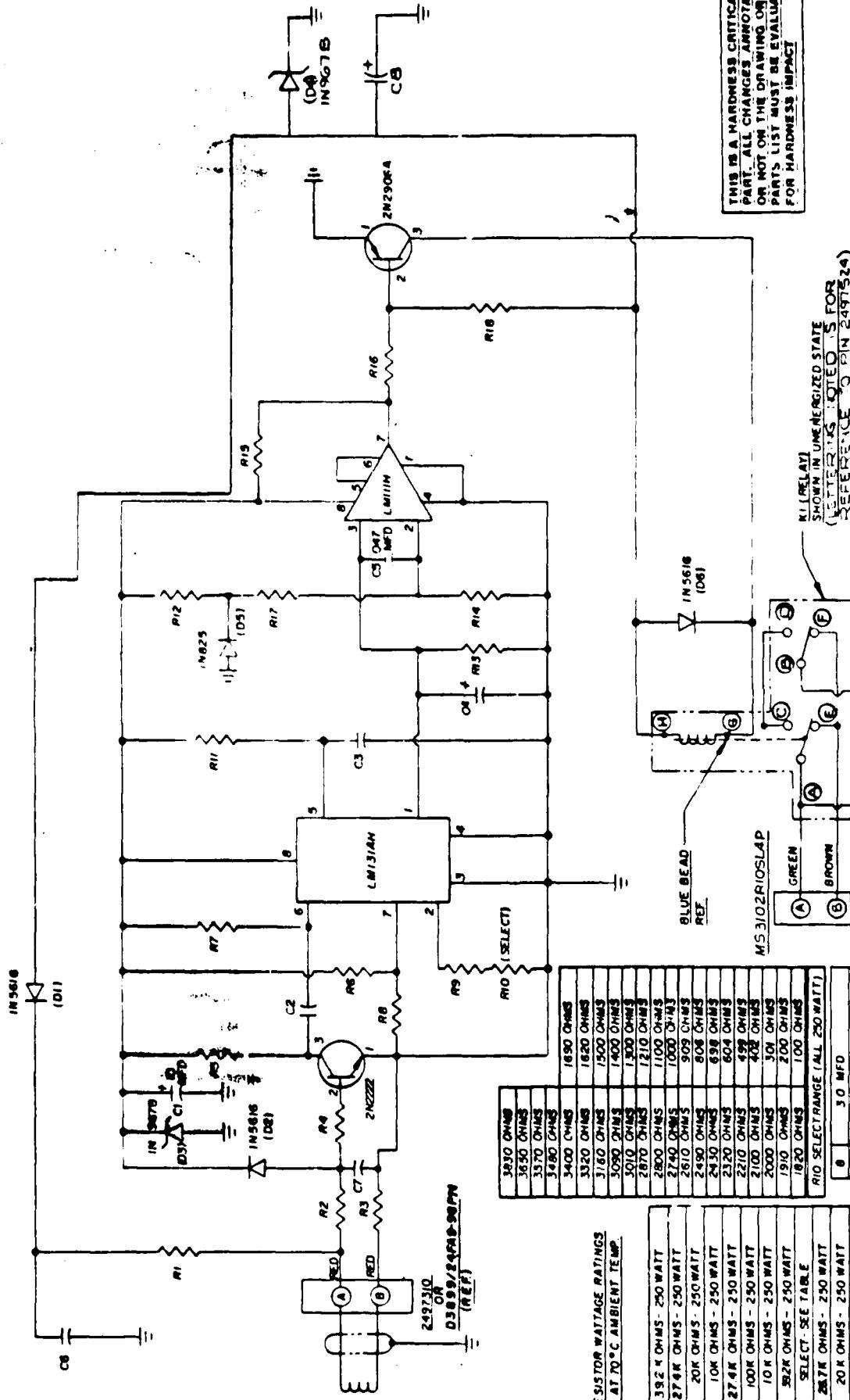
BOND AS FOLLOWS:

APPLY THIN COAT OF 3M TYPE EC1357
TO BONDING SURFACES OF BOTH
PARTS - PRESS FIRMLY TOGETHER

Allied Corporation		FIGURE 5
Bendix Fluid Power Division		
Ulster, New York		
CONTRACT NO.	3 MAY 85	
BR. C.W.	BR. C.W.	
TR.	TR.	
CR. B. 01/01/85	01/01/85	
NET. S.C. 01/01/85	01/01/85	
PROC. 01/01/85	01/01/85	
STA. 01/01/85	01/01/85	
DISP. ACTIV. 01/01/85	01/01/85	
PRINTED BY	01/01/85	
TEST AREA	01/01/85	
USED ON	01/01/85	
APPLICATION	01/01/85	
C 99551	2881034	
SCALE 1/1	SCALE 1/1	
SHEET 1	SHEET 1	

2581034

PRINTED ON 01/01/85 BY 01/01/85 FOR 01/01/85



NOTE -		ALL RESISTOR WATTAGE RATINGS TAKEN AT 70°C AMBIENT TEMP.	
18	39.2 K OHMS - 250 WATT	18	18.0 OHMS - 1800 OHMS
17	27.9 K OHMS - 250 WATT	17	16.0 OHMS - 1600 OHMS
16	20K OHMS - 250 WATT	16	15.0 OHMS - 1500 OHMS
15	10K OHMS - 250 WATT	15	15.0 OHMS - 1500 OHMS
14	27.9 K OHMS - 250 WATT	14	12.0 OHMS - 1200 OHMS
13	100K OHMS - 250 WATT	13	10.0 OHMS - 1000 OHMS
12	10K OHMS - 250 WATT	12	9.0 OHMS - 900 OHMS
11	39.2K OHMS - 250 WATT	11	7.0 OHMS - 700 OHMS
10	SELECT SEE TABLE		10.0 OHMS - 1000 OHMS

NOTE. ALL RESISTOR WATTAGE RATINGS TAKEN AT 20°C AMBIENT TEMP

NO.	RESISTANCE	NO.	CAPACITANCE
2	20 K OHMS - 250 WATT	6	30 MFD
7	10 K OHMS - 250 WATT	7	1500 PFD
6	10 K OHMS - 250 WATT	8	1500 PFD
5	10 K OHMS - 250 WATT	9	047 MFD
4	20 K OHMS - 250 WATT	4	10 MFD
3	400 OHMS - 2.5 WATT	3	01 MFD
2	400 OHMS - 1.2 WATT	2	330 PFD
1	400 OHMS - 2.5 WATT	1	100 MFD

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APPENDIX 2

PARTS LISTS

Reworked Parts for 36E133-6A ATS

<u>Qty.</u>	<u>P/N</u>	<u>Description</u>
1	2881074	Shaft, Rotor (reworked from 2487094)
1	2881073	Rotor, Turbine (reworked from 2487588)
1	2881045	Board Ass'y., Cutoff Switch (reworked from 36E153, P/N 2497332 Board)
1	2496167	Flange, Stator (changed for -6A)

New Parts for 36E133-6A ATS

1	2881079	Nut, Rotor
1	648894	Rotor, Generator (used on 36E153 ATS)
1	645199-4	Screw, Button HD (used on 36E153 ATS)
1	2881030	Stator, Air Turbine
1	2491278	Generator, Cutoff Switch (used on 36E153 ATS)
2	AN500 AD4-10	Screw, Fill HD
2	AN960C4L	Washer, Flat
1	MS20995C20-6	Wire, Tie
1	2881044	Adapter, Conduit
1	2881071	Shield, Braided Wire
1	2497500	Ring, Crimp
1	2497306	Elbow, Connector
1	2497307	Plug, Electrical Connector
2	645041H9SH	Screw, Soc. HD. CAP
2	AN960C10L	Washer, Flat
2	645167-1032	Nut, Hex
1	2881076	Plug, Housing
8	645041H7SH	Screw
2	645041H9SH	Screw, Soc. HD. CAP
2	MS20995C20-12	Wire, Tie
1	2881034	Box Ass'y. Speed Control
1	2881084	Data, Ident.

36E133-4A ATS Parts Replaced by New 36E133-6A

ATS Parts

<u>Qty.</u>	<u>P/N</u>	<u>Description</u>
1	2487123	Bushing, Pilot
1	645398S820	Nut, Lock, Thin
1	2491554	Contacts Ass'y. Governor Type
1	2491553	Housing, Assembly, Governor
1	2496169	Stator, Air Turbine
1	MS16555-627	Pin, Dowel
1	645001RR252	Gasket, "O" Ring
1	2494378	Conduit Ass'y., Electrical Connector
1	2491818	Gasket, Electrical Connector
2	645274-4	Tubing, Shrinkable
1	2494422	Connector, Electrical
4	645094G41DY	Screw, Socket, HD. CAP
2	MS20995C20-4	Wire, Tie
1	NAS620C4L	Washer, Flat
1	MS24677-3	Screw, Socket HD. CAP
1	MS20995C20-6	Wire, Tie
1	2494477	Data, Ident. Plate (MIL Type)

E U D

D T C

8 - 86